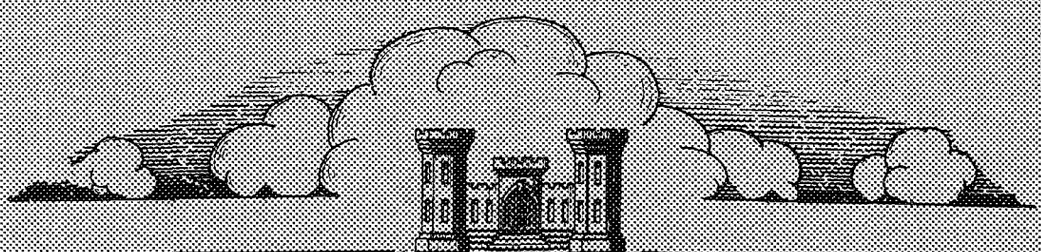
NARRAGUAGUS RIVER
MAINE

SURVEY REPORT

For

FLOOD CONTROL



CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION, BOSTON, MASS.

DECEMBER 1, 1949

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NEW ENGLAND DIVISION
CORPS OF ENGINEERS - U. S. ARMY
ARMY BASE, BOSTON 10, MASS.
DECEMBER 1, 1949

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SURVEY REPORT FOR FLOOD CONTROL

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SYLLABUS

The Division Engineer finds that ice-jam floods, augmented by dam failures, have caused considerable damage in recent years on the Narraguagus River at Cherryfield, Maine; and that these floods are of more frequent occurrence since the failure and abandonment of several small dams. He concludes that construction of a low rock-filled timber crib dam would relieve the difficulty from ice-jam floods at Cherryfield. However, as the benefits are not sufficient to justify the cost of construction and maintenance, improvement of the Narraguagus River for the control of ice-jam floods is not recommended at this time.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
ARMY BASE
BOSTON 10, MASS.

December 1, 1949

SUBJECT: Survey Report on Flood Control, Narraguagus River, Maine

TO: The Chief of Engineers, Department of the Army,
Washington 25, D. C.

ATTENTION: ENGWF

AUTHORITY

1. This report is submitted in compliance with Section 11 of the Flood Control Act approved July 24, 1946, Public Law 526, 79th Congress, 2d Session, which provides that:

> "The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control and allied purposes, including channel and major drainage improvements, and floods aggravated by or due to wind or tidal effects, to be made under the direction of the Chief of Engineers, in drainage areas of the United States and its territorial possessions, which include the following-named localities,****:
>
> Narraguagus River and tributaries, Maine."

Pursuant to this authorization a favorable preliminary examination report was submitted on September 22, 1947. A survey to determine the advisability and cost of improvement and the local cooperation required was recommended by the Board of Engineers for Rivers and Harbors and authorized by the Chief of Engineers in letter of December 5, 1947.

SCOPE OF SURVEY

2. This report is of survey scope. It considers means of controlling ice-jam floods on the Narraguagus River at Cherryfield, Maine. Field work has been limited to a topographic survey at the dam site, the drilling of two bore holes to determine the type of foundation material, and the development of high and low-water profiles in the vicinity of Cherryfield. State and local interests have been consulted, as well as interested Federal Agencies.

PRIOR REPORTS

3. There are no prior reports on flood control for the Narraguagus River with the exception of the preliminary examination dated September 22, 1947.

DESCRIPTION

4. Geography. - The Narraguagus River Basin is located in Hancock and Washington Counties in northeastern Maine, with center about 35 miles east of Bangor. The basin, which comprises approximately 240 square miles, has a length of 35 miles and a width varying from about 2 to 16 miles, averaging nearly seven miles. There are about 5 square miles of lakes and ponds and 16 square miles of swamp and marsh land within the watershed.

5. Topography. - The basin is characterized by broad, rolling, or almost flat lowlands, with isolated peaks scattered throughout the basin. Peaks along the limits of the watershed rise to heights of from 500 to over 1,100 feet above the adjacent valleys. The lower part of the basin includes small areas of cultivated land and extensive blueberry fields. The upper part is heavily wooded. The numerous hills and valleys are the surface expression of the gravelly sand and clay overburden of the glacial period. The present drainage is the result of an irregular overflow

through the glacial overburden and very little systematic drainage has been developed. Consequently, there is considerable natural storage and storm run-off is low. From explorations at the dam site it is expected that the bedrock is largely diorite and granite.

6. Main River. - The Narraguagus River rises in Eagle Lake, Township 34, Hancock County, Maine, flows in a general south - southeasterly direction for a distance of about 49 miles, emptying into Narraguagus Bay and the Atlantic Ocean about 20 miles northeast of Bar Harbor, Maine. The total fall of the river is 406 feet. Its slope between Eagle Lake and Cherryfield varies from about 4 to 14 feet per mile except for two localities. At DeBlois, about 15 miles above Cherryfield, a fall of 40 to 50 feet occurs within about one-half mile. Just above the village of Cherryfield the river drops nearly 50 feet within a distance of about 0.8 miles. Five rock-filled timber dams that were located within this section of the river have been destroyed and are no longer in existence. The river is tidal below Cherryfield with ranges of three to seven feet at Cherryfield and 10 to 14 feet at the mouth. A profile of the river through the village of Cherryfield is shown on Plate No. 3 submitted with this report.

7. Tributaries. - The only important tributary of the Narraguagus River is the West Branch which enters from the northwest, about 8.4 miles above the mouth of the Narraguagus. This tributary, which drains 80 square miles in the southwestern part of the basin, falls about 350 feet in its 22.5-mile length. Numerous small streams and brooks with relatively steep slopes also feed into the Narraguagus River and the West Branch.

8. Maps. - The Narraguagus River and its drainage basin are shown on standard quadrangle sheets of the U. S. Geological Survey, scale of 1:62,500, and on Plate No. 1 accompanying this report. The lower eight miles of the

river are shown on U. S. Coast and Geodetic Survey Chart No. 305 which gives the depths in the river up to Millbridge.

ECONOMIC DEVELOPMENT

9. Population. - The basin has a population of between 2,400 and 2,500. Millbridge and Cherryfield, located about two and seven miles above the mouth, respectively, are the largest towns in the watershed. The population and real estate valuations of these two towns are given below:

	Millbridge		Cherryfield	
Year	Population	Valuation	Population	Valuation
1900	1921	$469,800	1859	$518,700
1910	1550	429,600	1499	468,700
1920	1196	483,600	1304	486,900
1930	1207	487,200	1111	456,500
1940	1318	460,600	1046	417,000

The 1948 population of Cherryfield has been unofficially reported as about 1,120. Large portions of nine sparsely settled towns, with a combined population of less than 100, are also located in the basin.

10. Industry. - There has been a decline of lumbering and related industries within the basin and this has been the main cause for the loss of population during the past 40 to 50 years. At present approximately 63 people are employed in industries at Cherryfield which consist of two blueberry canning factories, one sawmill, a woodworking mill, and a hypodermic needle factory. One of the principal occupations of residents within the watershed is the accommodation of tourists, especially hunters and fishermen.

11. Transportation Facilities. - Cherryfield is on U. S. Highway No. 1 and is the eastern terminus of State Highway No. 182. There are few improved highways in the basin above Cherryfield. Rail facilities are furnished by the Washington County Railroad, a branch line of the Maine Central Railroad. There is no commercial navigation to Cherryfield.

HYDROLOGY AND HYDRAULICS

12. Precipitation and Temperature Stations. - There are no precipitation or temperature stations within the Narraguagus River Basin. Climatological information has been estimated from published records of the U. S. Weather Bureau for the following stations outside the basin:

Station	Distance from Center of Narraguagus Basin	Length of Record	
		Temperature	Precipitation
a. Bar Harbor	26 miles, southwest	50 years	63 years*
b. Ellsworth	23 " "	--	38 "
c. Oldtown	32 " northwest	29 "	34 "
d. Woodland	53 " northeast	21 "	30 "
e. Eastport	51 " east-northeast	73 "	73 "
f. Machias	28 " east	--	66 " **

*With breaks in record prior to November 1926.
**Records published since September 1926.

13. Temperature. - The annual mean temperature in the Narraguagus River Basin is about 44°F. The average January temperature ranges from about 22°F. along the coast to 18°F. in the northern part of the basin. The average July temperature ranges from about 65°F. to 68°F. for the same locations, respectively. Freezing weather can be expected by the end of September and is apt to continue until the end of April or early in May. Estimated average mean monthly temperatures for the basin are given in the following table:

TABLE I

MONTHLY TEMPERATURE RECORD

NARRAGUAGUS RIVER BASIN, MAINE

(Degrees Fahrenheit)*

Month	Coast	Inland	Basin
January	22.4	18.1	20.3
February	23.1	19.7	21.4
March	31.7	30.3	31.0
April	40.9	41.7	41.3
May	51.5	53.9	52.7
June	59.2	62.4	60.8
July	64.7	68.1	66.4
August	64.8	66.9	65.8
September	58.2	58.6	58.4
October	49.0	48.1	48.6
November	38.4	36.0	37.2
December	25.3	21.8	23.5
Annual	44.1	43.8	44.0

*Estimated from records for Bar Harbor, Eastport, Oldtown and Woodland, Maine, 1931 to 1947.

The average March temperature has been exceeded six times during the past 18 years, in 1931, 1936, 1942, 1945, 1946 and 1947, when the averages were from 2°F. to 5°F. above freezing. The average temperature for the first ten days of March has been about 27°F. This average has been above 32°F. only twice since 1931, in 1942 and 1946 when temperatures averaging about 35°F. were experienced.

14. Precipitation. - The average annual precipitation over the Narraguagus River Basin is approximately 41 inches uniformly distributed throughout the year. The maximum and minimum annual precipitation, estimated from records for four stations outside the basin, are 52.8 inches in 1936, and 31.7 inches in 1941, respectively. The estimated monthly precipitation records for the basin are summarized in the following table:

TABLE II

MONTHLY PRECIPITATION RECORD

NARRAGUAGUS RIVER BASIN, MAINE

(Depth in Inches)*

Month	Maximum Inches	Maximum Year	Minimum Inches	Minimum Year	Mean
Jan	9.3	1935	0.6	1944	3.5
Feb	8.5	1920	1.4	1941	3.0
Mar	7.4	1936	1.2	1924	3.6
Apr	7.3	1923	1.0	1941	3.8
May	7.3	1945	1.2	1944	3.0
Jun	7.1	1942	1.1	1941	3.4
Jul	5.4	1938	1.3	1935	2.9
Aug	6.3	1922	0.9	1947	2.9
Sep	8.0	1940	1.2	1923	3.9
Oct	8.1	1943	0.3	1947	4.1
Nov	7.3	1943	0.9	1939	3.9
Dec	7.6	1936	1.2	1943	3.4
Annual	52.8	1936	31.7	1941	41.4

*Estimated from records for Oldtown, Ellsworth, and Woodland, Maine, 1920 to 1947, and for Machias, Maine, 1927 to 1947.

15. The estimated precipitation over the watershed during periods of heavy rainfall, and during periods just prior to the floods of record, are listed below:

Month & Year		Dates	Inches	Dates	Inches	Total Inches
May	1945	10 to 11	1.9	13 to 19	3.3	5.2
Sep	1944	13 to 15	4.0	-	-	4.0
Oct	1943	16 to 17	3.5	19 to 20	1.3	4.8
Jun	1942	15 to 17	5.5	-	-	5.5
Mar	1942*	3 to 7	2.4	9	2.4	4.8
Apr	1940	12 to 13	3.8	-	-	3.8
Mar	1936*	12 to 13	2.6	18 to 21	2.1	4.7
Sep	1934	17	0.5	18	4.2	4.7
Oct	1932	27	2.3	28	1.9	4.2
Apr	1923**	28 to 30	4.2	-	-	4.2

* Dates of ice-jam flood occurrences.
** Flood occurrence without ice.

16. Snowfall. - The snowfall over the basin, estimated from records at five stations outside the watershed limits, has averaged about 68 inches for the past 27 winters. An estimated maximum depth of 122 inches occurred during the winter of 1922-23 and a minimum depth of 37 inches in the winter of 1932-33. The snowfalls during the winters preceding the 1936 and 1942 floods were approximately 63 inches and 57 inches, respectively, or five inches and eleven inches below the average.

17. Stream-Flow Records. - The U. S. Geological Survey established a recording stream gage on the Narraguagus River, just above the village of Cherryfield, in March 1948. Prior to this date there are no records of stream flow on the river. In the adjoining basin to the northwest a recording station, with a drainage area of 148 square miles, has been in operation on the West Branch of Union River, at Amherst, Maine, since July 1929. The nearest stream gaging station to the east is located at Whitneyville, Maine, on the Machias River. This station, with a drainage area of 457 square miles, has been in operation as a recording station since September 1929. It was operated as a chain gage station from October 1903 to September 1921. Maximum, minimum and average flow for Amherst and Whitneyville are given in the following table:

	Amherst	Whitneyville
Maximum Discharge		
Date	April 13, 1940	Sept. 30, 1909
c.f.s.	4,140	11,100
c.f.s. per sq.mi.	28.0	24.3
Minimum Discharge		
Date	Sept. 29, 1941	Oct. 12, 1939
c.f.s.	3.6	3.5
Average Discharge		
c.f.s.	264	955
c.f.s. per sq.mi.	1.8	2.1

18. The maximum discharge at five other gaging stations located within 50 to 80 miles of Cherryfield occurred between April 30 and May 2, 1923. The maximum discharge at a sixth station occurred on September 29, 1909 but this discharge was only two percent greater than that experienced in 1923. The lengths of record at these six stations vary from nearly 30 to nearly 50 years.

19. The maximum instantaneous flow of record on the Narraguagus River at Cherryfield, since installation of the gage, was 5,790 c.f.s. (25.0 c.f.s. per square mile) on May 19, 1948. The average flow for this date was 5,630 c.f.s. (24.3 c.f.s. per square mile). The corresponding daily average flows for the gages at Amherst and Whitneyville were 1,400 c.f.s. (9.5 c.f.s. per square mile) and 6,880 c.f.s. (15.0 c.f.s. per square mile), respectively. Studies of lower peaks at these three stations, for the short period of record at Cherryfield, also indicate a generally higher yield from the Narraguagus River than fom the Machias and the West Branch of Union River.

20. Floods of Record. - Cherryfield has been subjected to three damaging floods within the past 26 years. They occurred on or about March 9, 1942, March 20, 1936 and May 1, 1923. The greatest and most damaging was the flood of March 1942, which reached a height of 17.7 feet m.s.l., about 10 feet above the stage of ordinary freshets or 11 feet above extreme high tide. The main floor of the bank building, located about 175 feet above the east end of the bridge on U. S. Highway No. 1, was flooded 5 feet 2 inches deep in this flood. At the peak of the March 1936 flood the bank floor was 1 foot 11 inches under water. The flood of May 1923 is reported to have reached a stage of 11.2 feet m.s.l., over three feet below that of March 1936.

21. Owing to the absence of gaging stations there are no data whereby the discharge of the major floods on the Narraguagus River can be ascertained. The high stages experienced in the floods of 1936 and 1942 were mainly the result of ice conditions in the river. Heavy run-off was the sole cause of the 1923 flood. Estimated climatological data and records at stream gaging stations in neighboring basins indicate that the discharge on May 1, 1923 was probably one of the greatest ever experienced on the Narraguagus River. A further review of the estimated data reveals that climatological conditions prior to the floods of March 1936 and March 1942 were not unusually favorable for producing heavy run-off from the watershed.

22. Cherryfield was threatened with another serious flood in January 1945. A heavy rainfall during an unseasonable warm spell caused the river to rise and started a downstream flow of ice. This ice jammed at the frozen flats south of the lower highway bridge. Backwater from the jam flooded several cellars but serious damage was prevented by resorting to the use of explosives. It is reported that dynamite was also used to relieve the serious jam of 1942 and to break up a minor jam that occurred in 1944, with partial success.

23. Channel Capacity. - The bank-full capacity of the Narraguagus River at Cherryfield, taken at elevation 10.0 feet m.s.l., which is approximately the stage of zero damage, is estimated at between 9,000 and 12,000 c.f.s. without ice. The peak discharge in the 1923 flood exceeded the bank-full capacity by a small amount.

24. Frequency of Floods. - The frequency of damaging ice-jam floods at Cherryfield cannot be determined with any accuracy owing to the lack of records and the fact that such experienced floods have been coincident with

dam failures. It has been reported by local residents that ice jams have been occurring with greater frequency under present conditions than they did in the past. The upstream dams, prior to their destruction, retarded the flow of ice and held the sheet ice in place until it rotted in the spring. The uppermost of the five former dams, the one known as Stillwater Dam, was especially effective in this respect.

25. Standard Project Flood. - Consideration has been given to two possible conditions of damaging floods at Cherryfield; (1) a flood produced by rain, melting snow, or combination of both, where the flood stage is a function of discharge, and (2) a flood produced by ice, where the flood stage is primarily a function of the magnitude and effectiveness of the ice jam in addition to the discharge.

a. Flood Without Ice. - The meager hydrologic data for the Narraguagus River Basin and the extent of the local flood problem at Cherryfield has not justified an attempt to derive the usual Standard Project Flood for the Narraguagus River. The flood of May 1, 1923, which would cause only minor recurring damage, is the largest flood of recent times observed by the residents of Cherryfield. On several Maine rivers, some with discharge records for nearly 50 years, this particular flood is the largest of record, and it is surmised that it must have also been a flood of considerable size on the Narraguagus River, approximating a Standard Project Flood in magnitude. It is concluded that the flood history of the Narraguagus River does not indicate a serious flood problem and a Standard Project Flood, based on storm rainfall, has not been developed.

b. Flood with Ice. - Many indefinite and unpredictable factors are introduced in considering a Standard Project Flood involving

an ice jam. Some of the factors that complicate the problem and make any accurate analysis impossible, may be enumerated briefly as follows:

(1) The natural run-off in the river may be a minor flow, moderate, or even a flood run-off concurrent with adverse ice conditions.

(2) The extent of the winter ice and the rapidity with which it breaks up. Conditions are likely to be worse in a winter or early spring break-up when the ice is hard.

(3) The number of upstream ice jams that have occurred and the volume of ice accumulated before the ice arrives and piles up at Cherryfield. Each ice jam that has occurred upstream will leave some ice deposited along the banks, and perhaps reduce the volume of ice at Cherryfield. Also, the jams may cause the flow to back up and then break with a surge and cause a new jam further downstream. Such a condition would cause the river flow to be very irregular with alternate periods of low flow and high discharge occurring with practically a wave front.

(4) The extent of ice in the tidal reach of the Narraguagus River at Cherryfield and its condition at the time the river ice breaks up. Ice, reported seven to eight feet thick in the estuary, will raise stages at Cherryfield even without a jam.

(5) The condition of the tide at the time when the jam occurs at Cherryfield.

(6) The location where the jam forms and the height that the ice can build up before breaking up. Records of ice jams on other New England rivers indicate that ice jams raise the water stage from two to eight feet.

After considering the many problematical factors, it is concluded that it is impracticable to develop a Standard Project Flood involving ice

jams on the Narraguagus River. However, it is believed that a Standard Project Flood with ice may be considered as approaching the flood of 1942.

EXTENT AND CHARACTER OF FLOODED AREA

26. Approximately 65 acres of the commercial and residential center of Cherryfield, having an estimated valuation of $350,000, were inundated by the ice-jam flood of March 1942. Twenty-one homes and twenty-two commercial and public buildings are located within the flooded area. The principal commercial establishments include four general grocery stores, a paint store, a radio shop, a large garage and automobile salesroom, a service station, and the offices of two local business concerns. The public buildings include a hotel, a bank, the post office and two halls owned by fraternal organizations. The buildings in the flooded area are generally wood frame structures over 50 years of age but in good repair. Seven of the homes had from one to five feet of water on the first floors in 1942. Some of the commercial establishments and public buildings were flooded over five feet deep. The highways which parallel the river on both banks were eroded. Minor scour occurred at the bridge on U. S. Highway No. 1. The extent of the flooded area is shown on Plate No. 2 accompanying this report.

FLOOD DAMAGES

27. Experienced Damages. - The ice- jam flood of 1942 on the Narraguagus River at Cherryfield caused the loss of one life and total damages estimated at $132,000. This includes indirect losses in an amount of $36,000 to cover such losses as loss in business and wages, and costs of relief and evacuation. The flood of May 1923 is reported to have damaged Stillwater and several other dams and the railroad bridge

and caused the loss of at least two homes, a wooden highway bridge and a foot bridge, all above the commercial center of the village. The total loss probably exceeded $35,000. The experienced damage in the ice-jam flood of March 1936 is estimated at $20,000.

28. Recurring Losses. - The total experienced loss in the 1942 flood includes the loss of three dams, which have not been reconstructed, and damage to one building that was razed subsequent to the flood. These and other items of loss, which will not recur by reason of altered usage, have been taken into account in estimating the damages in future floods. Present price levels were also considered in determining the recurring losses. The experienced and recurring losses are summarized in Table III, below:

TABLE III

ESTIMATED FLOOD DAMAGES AT CHERRYFIELD, MAINE
NARRAGUAGUS RIVER

Type of Loss	Damage		
	1923 Flood	1936 Flood	1942 Flood
Experienced: Total	$35,000	$20,000	$132,000
Recurring			
Residential	2,000	5,000	20,000
Commercial	1,000	9,000	52,000
Public	500	2,000	8,000
Industrial	-	-	4,000
Highway	-	4,000	25,000
Total	$ 3,500	$20,000	$109,000

29. Minor damage in the nature of cellar flooding in several homes was occasioned by the ice-jam flood of January 1945.

30. Average Annual Losses. - The frequency of occurrence of ice-jam floods at Cherryfield is indeterminate. This makes it impossible to determine average annual losses by the usual method of correlating stage-damage and stage-frequency data. The experienced losses, both direct and indirect, for the three damaging floods of record since 1923, are estimated to have totaled nearly $190,000, an average of $7,600 per year for the period of 25 years since 1923. Average annual recurring losses will probably be less than this figure as the experienced losses include items of non-recurring nature such as dam washouts. Furthermore, future flood stages will not be augmented by the surge from dam failures as they were in the past. However, since the dams which formerly retarded the flow of ice were not replaced, the frequency of ice jams will be greater in the future than in the past. The total recurring losses for three floods of 1942, 1936 and 1923 magnitude are estimated at $132,500, or an average of $5,300 per year for a 25-year period. Although a period as high as 50 years might be taken, one of 30 to 35 years is considered to be reasonable for use in estimating annual losses. This is believed to be conservative in view of the fact that Cherryfield has experienced two severe ice-jam floods and one minor ice flood since 1936, the stages in two of the floods being lowered by using dynamite to blast the jams. On a fourth occasion the town experienced a jam that was broken up by the use of explosives before any flood damage was sustained. Considering the lack of hydrological information upon which to base a more accurate determination of average annual losses, $4,100 annually appears to be a reasonable figure to use in determining the economic justification of a flood-control project on the river.

EXISTING CORPS OF ENGINEERS' FLOOD CONTROL PROJECTS

31. There are no existing Corps of Engineers' projects in the Narraguagus River Basin.

IMPROVEMENTS BY OTHER FEDERAL AND NON-FEDERAL AGENCIES

32. There are no flood-control projects on the Narraguagus River. Five small rock-filled timber dams, constructed by private interests, were once located on the river at Cherryfield, but none are in existence at the present time. Four were used for power purposes in connection with the once flourishing lumber industry of the town. One was used for generating power for local use. Local interests report that three were washed out or destroyed by ice in March 1942, one was destroyed by fire in 1937, and one was abandoned over 30 years ago. The total power development at these five sites in 1911 was about 500 horsepower according to a report of the State Water Storage Commission. The locations of these old dams are indicated on Plate No. 2 accompanying this report.

IMPROVEMENT DESIRED

33. A well-attended public hearing was held in Cherryfield on May 6, 1947. The desire of local interests, as presented by the Board of Selectmen of Cherryfield, was for the construction of a flood-control dam on the Narraguagus River to eliminate the danger of future floods. It was stated that construction of a low dam at the Stillwater site, the uppermost of the five former dams at Cherryfield, would effectively control ice-jam floods and prevent damage in the town. No one voiced any objection to the improvement.

34. The proponents report that destruction of the three privately owned dams at Cherryfield, especially Stillwater Dam, has resulted in an urgent need for protection against ice-jam floods. The dam at Stillwater created a shallow reservoir of about 310 acres. This reservoir prevented the formation of serious ice jams in the Spring by retaining the ice until it melted. Local residents maintain that with the dams gone

they are now faced with the threat of an ice-jam flood each Spring. They estimate that serious jams may be expected to occur once in every four to eight years under present conditions.

35. The townspeople of Cherryfield claim that some form of flood protection is necessary if the present economic welfare of their community is to be maintained. They base their justification for improvement mainly upon the damages experienced in the flood of March 9, 1942. They fix the loss sustained by them in this flood at over $100,000. This estimate of their loss was supported by the returns received from an extensive flood-loss survey conducted by town officials. Four other floods were reported to have occurred since 1923. Explosives were used with partial success to break up ice jams in 1942, 1944 and 1945.

FLOOD PROBLEM AND SOLUTIONS CONSIDERED

36. General. - The flood damage at Cherryfield is caused by ice conditions in the spring freshet season. The two greatest floods of record were of the ice-jam type and were attributable in part to the failure of Stillwater Dam which caused a sudden release of the ice and water retained in the reservoir. The released ice formed a jam on the frozen flats a short distance downstream from the lower highway bridge in Cherryfield. The river was backed up by the jam until water and ice overflowed the banks of the stream and flooded the center of the town. The capacity of the river channel at Cherryfield is adequate for usual flood flows without ice as evidenced by the flood experience of May 1923 which caused only slight damage although this flood was the major flood in adjacent watersheds. The destruction of the small dams at Cherryfield, especially the dam at Stillwater, has resulted in conditions more favorable to the formation of ice jams. This is the contention of local

interests and it is borne out by the increased number of jams experienced since 1942, and the fact that no jams are recorded prior to 1936.

37. Ice Conditions. - Ice conditions are a major factor in the regimen of the Narraguagus River. Surface ice generally forms 18 to 24 inches thick on the upper river and its tributaries, and on the lakes or ponds within the basin, during the winter months. The fast, turbulent water in the rapids at Cherryfield is especially conducive to the formation of frazil ice in large quantities. Due to the high density of frazil ice as compared with sheet ice, which contains entrained air, the frazil ice submerges readily and eventually accumulates underneath the sheet ice cover. This probably accounts for the reported ice thickness of seven to eight feet at the upper end of the 4-1/2-mile tidal reach between Cherryfield and Millbridge. The ice conditions at Cherryfield are further aggravated by the formation of anchor ice. The ponds and reservoirs, which were numerous at one time in the Narraguagus River Basin, tend to diminish the quantity of ice in the lower reaches of the river as little or no frazil ice passes through the pools and the sheet ice is retained within the reservoir areas until it rots away or until after the break-up of the ice downstream.

38. Cherryfield is in a natural location for the formation of major ice jams. The ice flows, moving through the open water or thin ice in the rapids at Cherryfield, will slow down and tend to jam in the vicinity of the bridge on U. S. Highway No. 1, at the head of the ice-covered tidal pool.

39. Plans Considered. - Several general methods have been considered for providing protection against damaging ice-jam floods at Cherryfield.

a. Low Dam. - The construction of a low concrete or rock-filled timber crib dam at Stillwater, as proposed by local interests, would recreate the former Stillwater Reservoir. This would cause ice jams to occur at the head of the reservoir rather than in Cheeryfield. Normally the reservoir would either retain the ice until it rotted away in the Spring or delay its downstream movement until after the break-up of the ice in the 5-mile tidal reach between Cherryfield and Millbridge. The dam would also tend to diminish the quantity of ice in the lower reaches of the river as little or no frazil ice passes through pools or reservoirs. In effect this method of solution is based on restoring the reservoir that existed prior to experiencing ice jams. A dam about seven feet above the stream bed would be roughly the equivalent of the original structure at Stillwater. It would form a pool about 3-1/2 miles long extending up the Narraguagus River and the West Branch. The topography within the reservoir area is well suited to retaining an ice sheet or ice flows due to the low banks and meandering character of the stream and pond. A 5-foot dam would pond the water about a mile and a quarter up the stream. Overflow dams of concrete or rock-filled timber crib construction were considered. It is believed that a simple overflow dam, without gate operation, would be highly effective in controlling ice and preventing jams in Cherryfield. See Paragraphs 40 to 43 for further details. Any dam on the Narraguagus River, however, must be considered as a hazard to salmon even though a fishway is provided. It is reported that the Narraguagus River has become the best salmon stream in Maine since the old timber crib dams were washed out.

b. Random Rubble Dam. - A permeable barrier of random rubble construction at the Stillwater site was considered as an alternate to an overflow dam. The pond would remain low except in high-water periods when the structure would act much the same as an overflow dam. It would very likely be effective in retarding the flow of ice. However,

in the absence of a permanent pool, ice pressure against the structure would be of frequent occurrence and it is doubtful if such a structure could be made sufficiently stable to serve its purpose. The random rubble dam could be constructed for about one-half the cost of a rock-filled dam. Maintenance costs would be high. Owing to the uncertainties connected with this type of structure, no detailed estimates of cost have been prepared.

c. Other Ice-Control Structures. - Other structures given consideration included a heavy log boom and rock-filled timber cribs. The safety and effectiveness of such structures are uncertain and it is possible that they might be carried away by ice when most needed.

d. Dikes. - Protection from flood water could be provided by the construction of dikes along both banks of the Narraguagus River at Cherryfield. Nearly 1-1/2 miles of dikes would be required and it would be necessary to relocate several buildings that are situated on the river bank. The cost of dike protection would nearly equal the value of the property afforded security by the dike. No further consideration has been given to providing protection of this nature.

e. Annual Preventive Measures. - Consideration has been given to reducing the hazard of ice jams by annual remedial or preventive measures instead of constructing protective works of a permanent nature. Two methods may be employed, either separately or in combination. One method is to blast the ice jams as they occur, employing explosives such as dynamite or thermit. The second method is to secure and maintain an open channel in the lower section of the river so that the ice coming down the stream would have a clear passage to the sea. This has been accomplished on some rivers by

using cinders and chemicals, such as calcium chloride, to accelerate the deterioration and break-up of the ice in the Spring. It is believed that the cost for annual preventive measures would be about equal to one-half the annual cost of a timber crib dam. Local interests on several occasions have employed dynamite to relieve ice jams at Cherryfield, and met with partial success. They claim that the jams form very suddenly, with very little advance notice. Owing to the fact that the greater part of the jam is grounded, considerable time is required to blast a free-flowing channel through the ice. It is reported that three days were required to blast a half-mile length of channel. There does not appear to be sufficient depth of water beneath the ice to carry out successful blasting operations. Explosives used in conjunction with cinders and chemicals might prove effective on the Narraguagus, but there is considerable uncertainty regarding the success of this method as compared with a permanent structure, particularly in the case of an unseasonable thaw such as that of January 1945.

FLOOD CONTROL PLANS

40. General. - Construction of a dam is the only method for controlling ice jams at Cherryfield that has been given further consideration. The two types of dam considered feasible for construction at the Stillwater site are described in the following paragraphs.

a. Rock-filled Timber Crib Dam. - This plan consists of a rock-filled timber crib overflow section across the river with earth embankments retained by rock-filled timber cribs at both abutments. The overflow section would be 140 feet long with crest about seven feet above the river bed. The non-overflow sections would have a total

length of 350 feet and a maximum height of 20 feet. A fish ladder would be provided in the cribs at the right abutment.

b. Concrete Dam. - This plan consists of a concrete overflow section with earth embankments retained by concrete gravity walls at both abutments. The dimensions would be the same as those for the timber crib dam. The fish ladder would be located in the concrete wall at the right abutment.

MULTIPLE PURPOSE FEATURES

41. Limited consideration has been given to the use of a multiple-purpose reservoir at Stillwater for increasing low-water flow during the salmon season, reducing flood flows, recreation, power development and/or water supply.

a. A seven-foot ice-control dam at Stillwater would create a reservoir of about 310 acres, having a capacity of about 1,200 acre-feet. This pool could be drawn down during the dry summer months when there is insufficient water to permit the salmon to swim upstream. Low flows could be increased from about 15 to 20 percent over the driest two-month period. Against the advantages of increased low-flow, which are believed to be small, the following factors must be weighed:

(1) Use of the pool for recreational purposes would be largely eliminated.

(2) The installation of a gate would be required in the dam.

(3) A part time operator would be required.

(4) If a timber dam were constructed, the fluctuating pool levels would cause alternate wetting and drying of the timbers and thereby reduce the life of the structure and increase the cost of annual maintenance.

b. The Stillwater site appears from inspection to be suitable for the construction of a dam 30 to 40 feet above the stream bed. Twelve or more sets of buildings and about five miles of highway would be affected. The capacity of such a reservoir would be over 50,000 acre-feet or 4.0 inches on 230 square miles of drainage area. This capacity is not required or justified for the present flood-control needs of Cherryfield. Power storage at the site in conjunction with a penstock and power station one mile downstream from the dam, to obtain a gross head of 80 feet, would develop the power potentialities of the lower Narraguagus River. The capacity of such a plant at Cherryfield would be approximately 2,500 kilowatts. No investigation has been made of the cost or economics of power development, which does not appear particularly attractive and is not desired by local interests. The provision of water supply in a multi-purpose project is desired by the town of Cherryfield although it is not in a position to finance such a project. It is believed that the cost of a multiple-purpose development would exceed the benefits derived.

RECREATIONAL DEVELOPMENT

42. There is no apparent need for a permanent pool for recreational purposes. However, residents state that the original pool at Stillwater was used to a limited extent for swimming and other recreational purposes. It is likely that a pool formed by a new dam would serve similar purposes and afford attractive sites for summer cottages and year-round homes.

ECONOMICS

43. Costs. - A summary of the Federal and non-Federal first costs and annual costs for the two types of dam described in Paragraph 40 is given in Table IV, below. The Federal costs include construction costs, engineering and overhead. Costs of lands, damages and annual maintenance would be borne by local interests. Interest on the Federal investment

has been computed at 3 percent and on the non-Federal investment at 3-1/2 percent. The projects would be amortized over 50 years.

TABLE IV

SUMMARY OF COSTS

Plan of Improvement	First Costs			Annual Costs		
	Construction	Lands & Damages	Total	Federal	Local Interests	Total
Rock-filled timber crib dam	$118,000	$3,000	$121,000	$4,600	$1,100	$5,700
Concrete dam	176,000	3,000	179,000	6,900	700	7,600

44. Benefits. - The construction of a low dam at Stillwater will prevent the formation of serious ice jams at Cherryfield and afford the town practically complete protection from floods associated with ice jams. It is believed conservative to assume that the ice-control structures will prevent 90 percent of the damage. This allows for uncertainties of ice movement and jam formation in periods of high stream flow and the fact that no protection is provided against rare floods without ice, such as occurred in May 1923. It follows that, with annual damages estimated at $4,100, annual benefits would equal $3,700. No other benefits have been assigned.

45. Comparison of Benefits and Costs. - Comparing the annual charges for a dam at Stillwater with the annual benefits of $3,700 gives a benefit-cost ratio of 0.7 for a rock-filled timber crib dam and 0.5 for a concrete dam.

PROPOSED LOCAL COOPERATION

46. The benefits from an ice-control structure at Cherryfield are predominantly local in character and the improvement is in effect a local

protection project. For such a project local interests would be required to cooperate to the extent provided in Section 3 of the 1936 Flood Control Act, as follows:

a. Provide without cost to the United States all lands, easements and rights-of-way necessary for the construction of the project.

b. Hold and save the United States free from damages due to the construction work.

c. Maintain and operate the works after completion in accordance with regulations prescribed by the Secretary of War.

47. The town of Cherryfield has made no definite commitments regarding local cooperation. The town selectmen have gone on record, however, as being ready to recommend to the townspeople that they accept the conditions set forth above. An appropriation of $2,500 that was made by the State "to aid in construction of piers at Stillwater on the Narraguagus River for protection of two concrete bridges******" can be applied towards local cooperation.

COORDINATION WITH OTHER AGENCIES

48. All known Federal and State agencies that may have had an interest in the desired improvement of the Narraguagus River were notified of the public hearing held in connection with the considered project. Conferences were held with representatives of the Department of Inland Fisheries and Game, State of Maine, and the U. S. Fish and Wildlife Service, Department of the Interior, to ascertain the needs and desires of fishing interests. The type and location of the fishway to be provided in the dam were determined on a cooperative basis with these agencies. The U. S. Fish & Wildlife Service considers the Narraguagus River to be one of the best salmon streams on the eastern coast of the United States and is endeavoring, along with State interests, to improve the river for salmon fishing.

49. In compliance with the provisions of Public Law 562, 79th Congress, the Public Roads Administration, Federal Works Agency, and the State Highway Commission were contacted relative to a highway bridge across the dam. Neither agency desired provisions for a combined bridge and dam structure at Stillwater.

DISCUSSION

50. The occurrence of serious floods on the Narraguagus River is of comparatively recent origin and there is no history of repeated floods. The flood problem has arisen largely owing to the gradual disappearance from the river of privately-owned dams installed for creating pools for lumber operations, and the incidental piers and booms used in connection with the dams, which all had their part in holding the ice in ponds where it rotted away. Under present conditions ice jams are of frequent occurrence at the head of the tidal pool in Cherryfield. Damages in Cherryfield have been considerable in relation to the value of the property affected. The losses from high water and ice in the flood of March 1942 are estimated at $130,000 and one life was lost. Damaging floods also occurred in May 1923 and March 1936. Explosives were used in 1944 and 1945 to prevent flooding from ice jams. The principal floods were augmented by failure of Stillwater Dam. The average annual recurring loss is estimated at $4,100. (See Paragraph 30).

51. The most suitable plan of improvement is the construction of a dam. Past experiences on the river indicate that such a structure would be effective in preventing ice-jam floods. Ice is retained in the reservoir until it melts in the Spring. It is believed that either the rock-filled timber crib dam or the concrete dam would serve the purpose and afford benefits of $3,700 annually. The benefits are not sufficient to justify a cost of $121,000, equivalent to $5,700 annually, for the timber

crib dam. The concrete dam is even more costly. The timber crib dam has a benefit-cost ratio of 0.7.

CONCLUSION

52. In view of the fact that Cherryfield experienced no difficulty from ice jams while Stillwater Reservoir was in existence, it seems reasonable to conclude that restoring the pond by the construction of a low overflow dam, as proposed by local interests, would alleviate the troublesome ice-jam situation at Cherryfield. A rock-filled timber crib dam would serve the purpose but cannot be economically justified.

RECOMMENDATION

53. It is recommended that no improvement of the Narraguagus River for the purpose of controlling ice-jam floods at Cherryfield, Maine be undertaken at this time.

B. M. HARLOE
Colonel, Corps of Engineers
Division Engineer

Inclosures:
- Plate No. 1 - Plan of Narraguagus River Watershed, File No. NA100-1/1
- Plate No. 2 - Narraguagus River at Cherryfield, File No. NA100-1/2
- Plate No. 3 - Profile of Narraguagus River, File No. NA100-1/3

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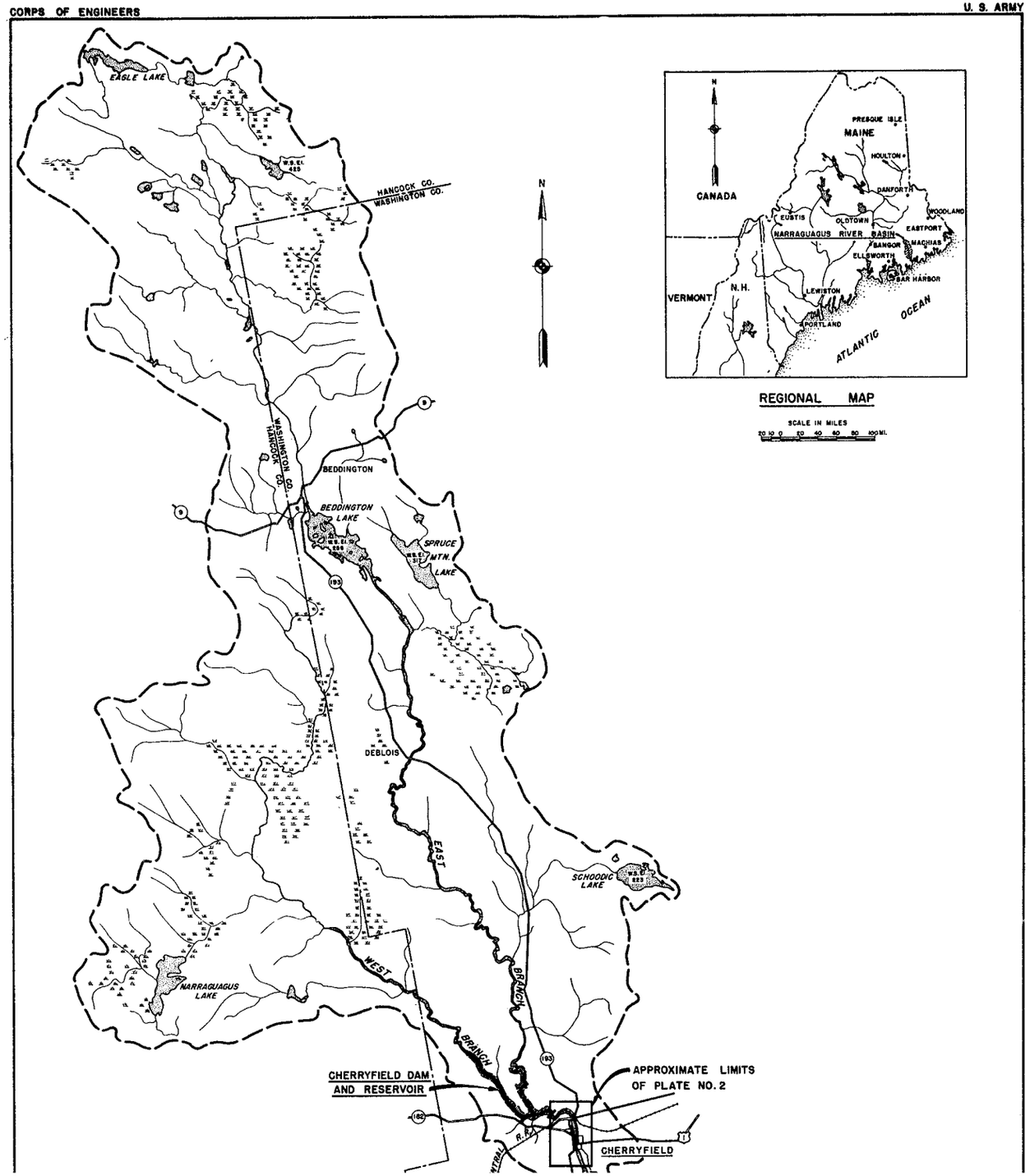

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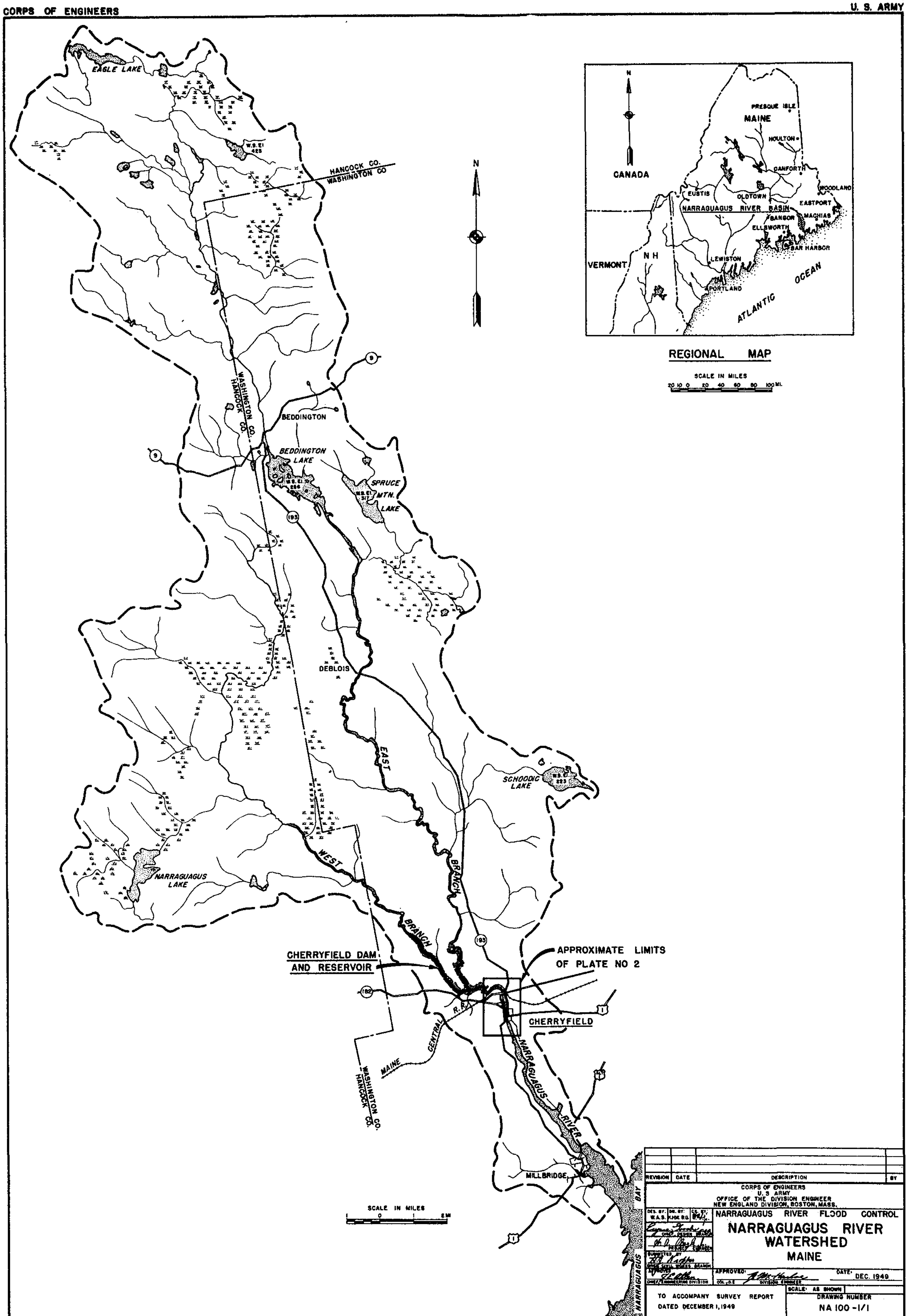
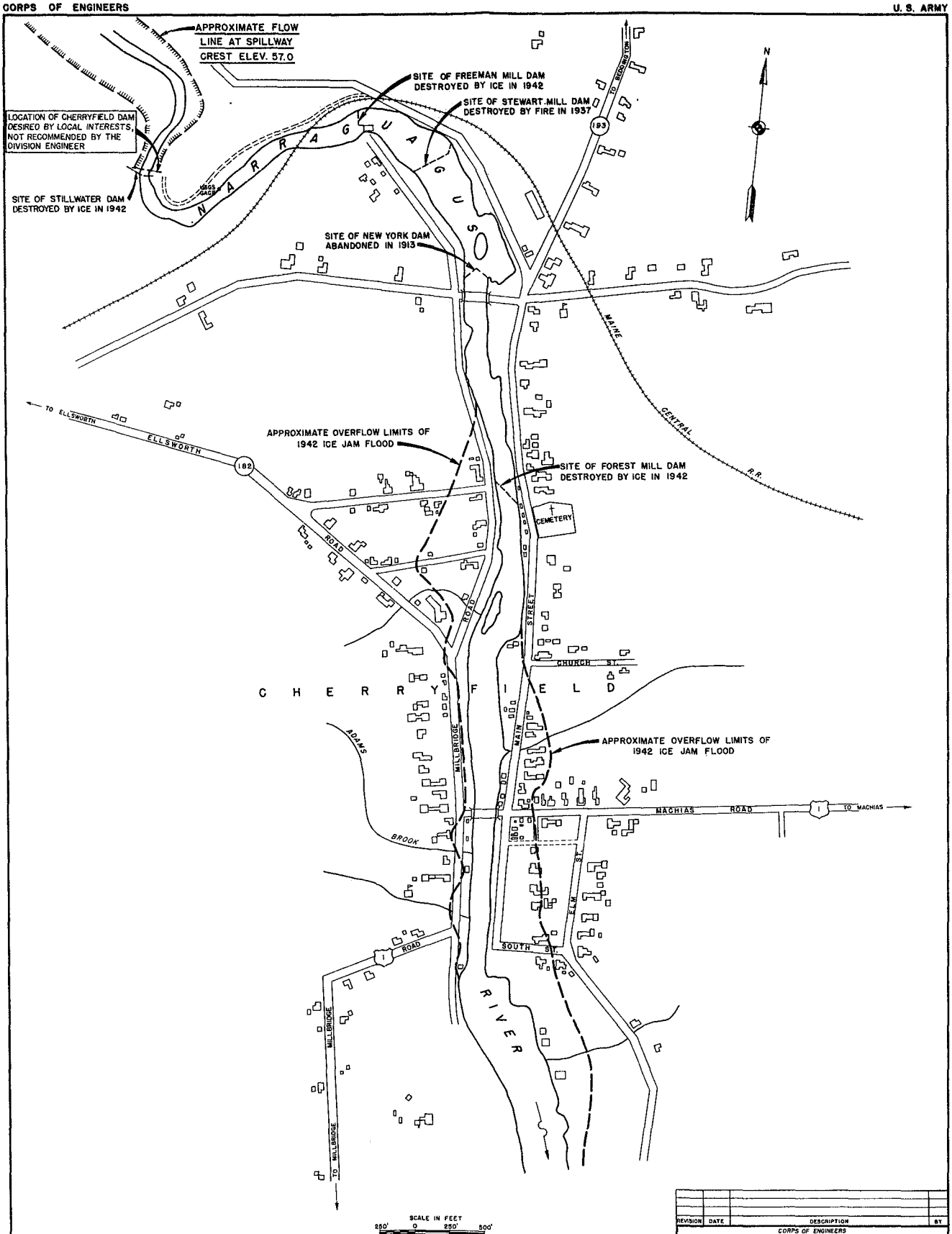


PLATE NO I



REVISION	DATE	DESCRIPTION	BY

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U.S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION, BOSTON, MASS.

DES. BY W.A.S. | DR. BY A.G.G. | CK. BY

NARRAGUAGUS RIVER FLOOD CONTROL

NARRAGUAGUS RIVER AT CHERRYFIELD, MAINE

SUBMITTED BY: CHIEF, CIVIL WORKS BRANCH

APPROVED: CHIEF, ENGINEERING DIVISION

APPROVED: DIVISION ENGINEER

DATE: DEC. 1949

TO ACCOMPANY SURVEY REPORT DATED DECEMBER 1, 1949

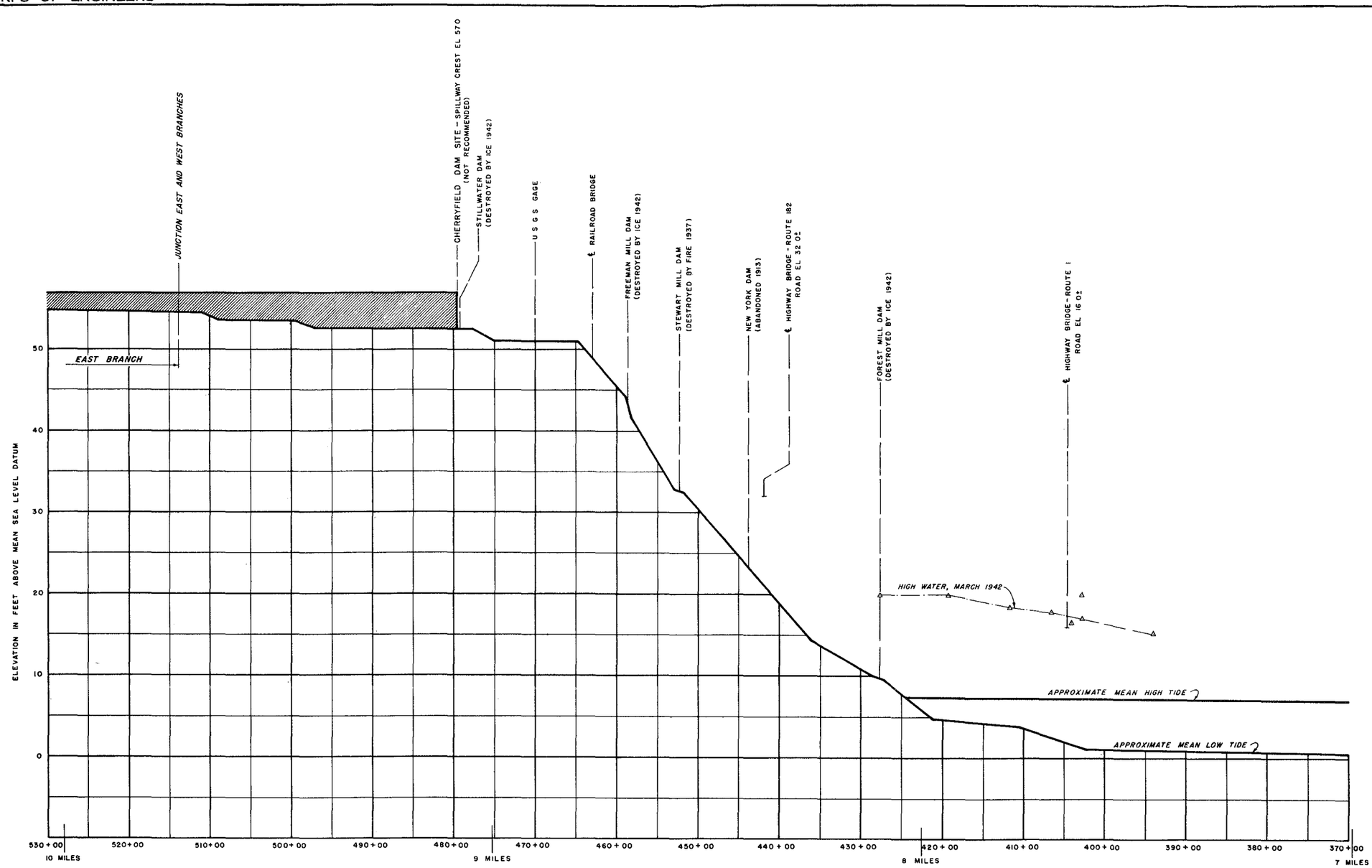
SCALE: AS SHOWN

DRAWING NUMBER NA 100-1/2

PLATE NO.2

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

△ HIGH WATER MARK OF MARCH 1942

RESERVOIR AT SPILLWAY CREST

NOTES

ELEVATION IN FEET ABOVE MEAN SEA LEVEL DATUM.

STATIONING IN FEET ABOVE ENTRANCE TO DREDGED CHANNEL IN NARRAGUAGUS BAY.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DES BY	DR. BY	CK. BY
W.A.S.	B.G.	

CHIEF, DESIGN BRANCH

PROJECT ENGINEER

SUBMITTED BY

CHIEF, CIVIL WORKS BRANCH

APPROVED

CHIEF ENGINEERING DIV.

NARRAGUAGUS RIVER FLOOD CONTROL

PROFILE

NARRAGUAGUS RIVER

CHERRYFIELD MAINE

APPROVED

COL., C.E., DIVISION ENGINEER

DATE DEC. 1949

TO ACCOMPANY SURVEY REPORT DATED DECEMBER 1, 1949

SCALE AS SHOWN | SPEC. NO.

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SHEET OF

PLATE NO. 3